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Technical and social knowledge discontinuities in the multi-objective management of private forests in Finland

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ABSTRACT

Managing forests sustainably for multiple objectives requires multi-faceted socio-technical knowledge. This study explores the challenges of using knowledge within social and technical knowledge systems in decision-making about and the management of privately-owned forests in Finland. We define the technical knowledge system as the collection of standardized forms of knowledge and the IT systems supporting their storage and distribution. The social knowledge system consists of people who use and generate knowledge, as well as the societal norms that regulate their actions. We draw from two data sources: focus group discussions with representatives of forest and environmental stakeholders (n = 60) and notes from forest professionals' (n = 35) training workshops. Theories of knowledge management and knowledge lifecycle frame the analysis. We identify problems with knowledge use that are related to the functioning of both the technical and social knowledge systems, as well as to the mismatch of these systems. The results show many points of discontinuity in the flow of knowledge within and between forest-related actors and organizations. To enhance the knowledge flows, more attention must be paid to i) social structures that guide the ways in which knowledge is used and validated in the organizations, and ii) a more balanced manner to produce and co-utilize different forms of knowledge.

1. Introduction

Managing ecosystem services and human well-being requires knowledge of complex socio-ecological systems (Dietz et al., 2003) as well as a better understanding of how to pursue socio-technical change (Miller et al., 2014). More effective production and distribution of knowledge with new, flexible information and communication technology tools has enabled new people and organizations to participate in decision-making, which has changed the roles of the state and experts that previously led environmental action and produced centralized expert knowledge (Mol, 2006; Soma et al., 2016). This also applies to forests owned by private individuals, which are of increasing societal interest (Kline et al., 2000) for their multiple benefits to societies like clean air and biodiversity (Markowski-Lindsay et al., 2016) and renewable raw materials for industries. Knowledge ecosystems and knowledge management systems have been studied in the context of forest use from several viewpoints (e.g. Thompson, 2007; Vacik et al., 2013; Van Horne and Marier, 2005). Still, there are gaps in the understanding of how new, integrated socio-ecological knowledge may be effectively applied at the very practical level of private forest management for multiple objectives.

Improving information for the governance of socio-ecological systems is often seen as a matter of improving the quality of datasets that contain relevant measurable variables for environmental characteristics (Lehtonen et al., 2016; Mol, 2006). This scientific-technical approach concentrates on knowledge about nature and puts emphasis on the generation of knowledge and support systems with the aim of maximizing the effectiveness of the measures taken (Primmer et al., 2015). It relies on scientific knowledge and an assumption of smooth knowledge flows (Primmer et al., 2015) and the objectivity of the knowledge (Fortmann and Ballard, 2011). In this study, the collection of standardized data and the IT systems supporting its storage, distribution and application are collectively referred to as the technical knowledge system. The technical knowledge system has been emphasized in

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Western companies and organizations that have mainly focused on developing new applications for information technology to support the acquisition, storage and distribution of codified knowledge (Grover and Davenport, 2001).

Multi-objective management of privately-owned forests combines a variety of knowledge from different sources. Different local, regional and national agencies and groups hold relevant knowledge (Berkes, 2009). Efficient decision making based on knowledge dispersed among a network of different knowledge sources demands smooth information flows within and between individual actors, actor groups and organizations (Primmer, 2011; Primmer and Wolf, 2009; Sandström, 2009). These flows are affected by a range of factors such as attitudes of individuals, organizational strategies, available resources and the social context (e.g. Maier and Winkel, 2017) as well as cognitive psychological or behavioural factors (Kaiser and Fuhrer, 2003). The individual actors and their organizations using and generating forest-related knowledge, the social and societal norms that regulate their actions, and the ways in which they take advantage of the technical knowledge systems, together constitute the social knowledge system (He et al., 2009; Tsoukas, 1996).

In this paper, we focus on the interplay between technical and social knowledge systems as well as on the use of different forms of knowledge. The study contributes to an improved understanding of how different knowledge systems are interconnected in and influence forest management and planning practices. We investigate how knowledge is utilized in decision making about the use of forests owned or co-owned by private individuals in Finland, how it could be taken advantage of more effectively, and why the information needed is still not available or utilized. Our interest is the advising for and implementation of the forest owners' decisions, hence the focus is on the multi-actor knowledge systems related to these processes. Earlier research has found discontinuities in the flow of information within and between the forest and environmental organizations (Hokajärvi, 2012; Primmer, 2011; Saaristo et al., 2017). These discontinuities induce inefficiencies in the conservation of biodiversity and jeopardize the realization of forest owners' objectives in the management of their forests. To shed light on the reasons for these discontinuities and inefficiencies, we explore the following four research questions:

1) What roles do different forms of knowledge (codified, encapsulated or tacit) play in the multi-objective management of privately-owned forests?
2) How do technical and social knowledge systems interlink in these (decision-making and) management processes?
3) What are the reasons for discontinuities in information flows within and between forest-related actors?
4) What solutions and positive developments have organizations identified or developed to enhance information flows?

2. Conceptual framework – knowledge systems and forms of knowledge

2.1. Technical and social knowledge systems

Knowledge and technological systems related to knowledge are always dependent on the time, place and people producing them (Blackler, 1995; Jasanoff, 2004). The technical knowledge system is embedded in the social knowledge system: the decisions on how technical knowledge management systems are built and what data are collected are socially directed (Jasanoff, 2004). Technologies are useful in enhancing the information flows within the organization and enabling coordination between relevant operators by minimizing human and physical constraints (Bhatt, 2001). Ways to use these technologies are determined by the functioning of the social knowledge system. Effective knowledge management requires an interplay of technical and social knowledge systems in an organization and on the level of individuals working in and with those organizations (Bhatt, 2001). Social relationships are a key factor affecting knowledge-sharing behaviour (He et al., 2009). Primmer and Karppinen (2010) found that social professional norms have an even stronger influence than attitudes on how forest professionals judge new information about, for instance, biodiversity conservation measures. Because knowledge and knowing is always socially determined, they are also a question of power relations. Someone's credibility as a knowledge producer depends on social markers, such as education (Fortmann and Ballard, 2011).

2.2. Knowledge management lifecycle

Knowledge management includes systematic processes for producing, collecting, distributing and applying all forms of knowledge (Alavi and Leidner, 2001; Dalkir, 2011). This *knowledge management lifecycle* is defined as a chain of knowledge activities that happen after each other (Nissen et al., 2000). In practice the phases take place iteratively (Nissen and Espino, 2000). Fink and Ploder (2009) define the key process phases as following: in *knowledge acquisition* an organization needs to acquire certain forms of knowledge outside the organization through generating new knowledge by themselves (e.g. by forest inventories) or through collecting existing knowledge from customers or other knowledge sources (such as from official databases). *Knowledge distribution* means sharing an organization's existing knowledge within itself and with partners, e.g. subcontractors or customers. In *knowledge utilization,* the knowledge is applied productively to carry out organizational activities. Despres and Chauvel (1999) add the concept of evolvement to the lifecycle, meaning that knowledge must evolve when the environment changes in order to stay relevant. This is also known as adaptation. Dynamism of knowledge systems enables them to constantly respond to changes in the operational environment and adapt to new knowledge (Battiste, 2005).

2.3. Forms of knowledge

Knowledge management theories build on the understanding that organizational knowledge has several forms or shapes (Evans et al., 2014) that determine how the knowledge can be stored and distributed. These are divided into three categories: data, information and knowledge (Bhatt, 2001; Grover and Davenport, 2001). Data are raw bits of information, whereas information is a classified or summarized set of data within a certain context. Knowledge is meaningful information that always includes human interpretation or processing of that information and hence has the greatest relevance to action. Knowledge is always dependent on the person using and developing it and because of this dependence on human contribution to its existence, knowledge is also the most difficult to manage of these three forms (Grover and Davenport, 2001). Bell (1979) describes knowledge as an "organized set of statements of facts or ideas, presenting a reasoned judgment or an experimental result, which is transmitted to others through some communication medium in some systematic form". Data can be converted into information by automated data processing, but only people can interpret information and turn it into knowledge and then interpret, communicate and analyze it from different perspectives (Bhatt, 2001). The form of knowledge dictates the cost and benefit of acquiring it and affects how it can be transferred (Van Den Berg, 2013).

Knowledge is commonly further divided into explicit and tacit knowledge (Grover and Davenport, 2001). Explicit knowledge is usually defined as easily codified and formally expressed using a system of symbols like words or formulae (Van Den Berg, 2013) or as being "describable and tangible" (Wiig, 1993, p. 65). According to this definition, explicit knowledge is codified knowledge. Codified knowledge is highly formalized (Van Den Berg, 2013) and codified by rules, standards and classification systems (Choo, 1996). Examples of this type of knowledge are automated forest inventory data or registers with customer contact information. The distinction between codified knowledge and information is blurred as they have many common features. Both are easily stored or written down without losing parts of the content (Evans et al., 2014).

However, not all explicit knowledge is explicit in the sense of being readily observable and standardized between sender and recipient. Van den Berg (2013) distinguishes between codified and encapsulated knowledge. Encapsulated knowledge consists of the thought, reflection or experience of its creator, and offers the functional value of the creator's expertise to the receiver although the primary expertise stays concealed (Van Den Berg, 2013). Typically, the encapsulated knowledge has been transformed into a product that only requires functional knowledge for its utility (Van Den Berg, 2013), e.g. patents or tools (Choo, 2006, p. 141), but it can also be instructions or procedures. Software is an example of encapsulated knowledge; the user receives functional benefit from it without needing to know how the code behind it works. Encapsulated knowledge is commonly intra-organizational. A forestry-related example of encapsulated knowledge is the recommendations for forest management: forest owners benefit from the knowledge of how to best manage their forests even if they are not familiar with the scientific reasoning behind the recommendations.

Encapsulated knowledge is similar to tacit knowledge since they both are difficult or impossible to capture in a structured form and require prior knowledge from the recipient for correct interpretation. Tacit knowledge is personal and action-oriented and typically considered as non-conscious or internalized (Wiig, 1993, pp. 135–136). It is practical know-how, skills or expertise that accumulates over time through experience or by learning (Kogut and Zander, 1992). As tacit knowledge is embedded in the human brain (Grover and Davenport, 2001), it is expensive to transfer and distribute (Kogut and Zander, 1992). Tacit knowledge of an employee is needed to interpret and process codified knowledge or data sets constituting codified knowledge (David and Foray, 2002).

Knowledge management, including the knowledge lifecycle and different forms of knowledge, takes place within the knowledge systems. Certain forms of knowledge are more typical for the technical knowledge system and other forms occur more typically in the social knowledge system. Furthermore, in addition to the forms of knowledge, several types of knowledge can be distinguished: for example scientific, non-professional or local knowledge (Berkes et al., 2000; Fortmann and Ballard, 2011; Giessen and Böcher, 2009). Local knowledge is related to local places and people, and produced and utilised by them (Geertz, 2000; Salomaa et al., 2016). Non-professional knowledge is produced by a person who has no professional status by education or occupation concerning a certain subject, and the knowledge is based on their experiences and the social norms on interpreting those experiences (Bamberg, 2013). These various types of knowledge may take different forms.

3. Materials and methods

3.1. Study context – Finnish forests, forest management and policy

Our study area is Finland, where 86% of the land area is productive forestland (Natural Resources Institute Finland, 2018) and 60% of forests are owned alone or jointly by individuals (Leppänen and Torvelainen, 2015). Altogether, within the 5.5-million population, there are about 630,000 people owning at least two hectares of forest, with an average holding size of 30.1 ha (Leppänen and Torvelainen, 2015). Although forest owners are independent decision-makers about their forests, they typically give a high value to professional advice (Hujala et al., 2007). Because of the great number of small-scale forest owners (FO) and the financial importance of the forest sector for Finland (Rantala and Primmer, 2003), there is a long tradition of FOs receiving advisory services from the forest administration and from market-oriented timber procurement and forest management service providers. This advice has long been based on scientific knowledge on how to maximize timber production (Peltola and Tuomisaari, 2016). During the last decades, environmental authorities and non-governmental organizations (NGO) in the environment sector have also gained influence in forest-related decision making. Also a growing proportion of forest owners expects their forests to be managed so that they provide other ecosystem services besides timber (Pynnönen et al., 2018).

Forest professionals represent different organizations and work as mediators interpreting forest management regulations and hence shape forest policy outcomes while brokering knowledge within their publicly funded or business activities (Lidskog and Löfmarck, 2016). Different organizational strategies affect practices and hence the professionals have different resources and objectives when they meet with FOs. These organizational preconditions affect the ways experts recognize and consider knowledge from different sources or of different types.

In this study, the forest professionals included forest authorities and forest service providers. Forest authorities' tasks in Finland consist of producing and providing information about forest resources and their management for FOs and service providers through training and informing. They promote sustainable use of forests and strengthen the competitiveness of the forest sector. They also implement state funding schemes for the conservation of biodiversity through multi-objective forest management. Environmental authorities are responsible for the production and provision of environmental information and implementation of biodiversity conservation measures. This includes the state-funded biodiversity conservation programme METSO (later Biodiversity Programme) that since 2008 has targeted voluntary conservation in private forests. Forest owners may offer their forest sites for the Biodiversity Programme and receive monetary compensation if the sites are accepted depending on certain science-based criteria for biodiversity values (Government of Finland, 2014). Forest and environmental authorities work under the responsible ministries and hence implement the forest and environmental policies. They can both enter into conservation contracts with forest owners, with a somewhat different set of means (Vainio et al., 2018). Both work on regional level and their co-operation is usually good.

The work of forest service providers is still largely driven by the traditional roundwood market needs (Mattila et al., 2013) and hence concentrates on timber production and procurement (Peltola and Tuomisaari, 2015). Forest management associations (FMA) are local service organizations that forest owners themselves administer. They employ foresters and forestry engineers to advice FOs about the use of forests, produce information by compiling holding-level forest management plans and assist the FOs in conducting timber sales e.g. by making the operational plans and instructions for harvesting or management works. FMAs make their revenues mainly as a percentage of timber sales they facilitate, but lately they have made efforts in developing also multi-objective services, e.g. they forward proposals on potential Biodiversity Programme sites from their customers to the forest and environmental authorities. Timber-buying companies concentrate on procuring timber effectively. They are however also committed to a wide range of environmental programmes and their formal strategies feature multi-objectivity. These companies also offer forest owners forest management and other expert services. Lately, new actors have entered the forest service field, but these enterprises are still small and local and in many cases work in co-operation with FMAs.

Incorporating biodiversity conservation and multiple uses of forests into forestry has required considerable changes in the expertise and knowhow of forest professionals and in how the organizations work. The diminishing public funds for forest and environmental administrations are in stark contrast to the increasing need to produce more information on biodiversity hotspots and recreationally important areas, and to integrate public and private demands on these. The burden of knowledge production has partially shifted to environmental NGOs whose volunteers (usually educated biologists or dedicated hobbyists) conduct species inventories and observations and forward their knowledge to authorities and other actors.

In their advisory position, the professionals who prepare operational plans for harvesting and silvicultural practices for privately-owned forests play a significant role in executing biodiversity or habitat conservation (Primmer and Wolf, 2009). These professionals represent usually FMAs or timber procurement companies. In practice they bear the landowner's responsibility to safeguard the natural value of the management site (Peltola, 2013). Their competencies in conducting multi-objective forest management as well as their attitudes towards different forest uses and forest owners affect how they validate different forest-related knowledge and distribute it to the FOs. Forest owners may be encouraged towards increasing cuttings (Peltola and Tuomisaari, 2016), deadwood, or game habitats, or a mix of these.

3.2. Collection of two-fold data

The data of this study were drawn from two sources: recorded focus group discussions and notes from training workshops. The data were collected as a part of a larger, multi-disciplinary and practice-oriented research project. The focus group discussions and training workshops were conducted in the spirit of participatory action research, emphasizing the participatory character of the data collection and enhancing communication and cooperation between the research participants.

The first part of the data consists of nine focus group discussions. These were organized at three locations in May and November 2014. Altogether 60 participants represented forest and environmental administration, landowners, forest professionals and other stakeholders such as environmental NGOs. As knowledge generation and distribution takes place in and between different actors and organizations (Hafkesbrink and Schroll, 2011), we aimed to have a diverse group of participants in each discussion. The selection of focus group discussion participants was based on key informants' knowledge of relevant conservation and forestry actors in each area. A more detailed description of the participants is recorded in Annex A.

The aim of the focus groups was to initiate dialogue among a varied group of stakeholders that possessed multifaceted forms of knowledge. The participants represented different actors that play a role in FOs' forest-related decisions e.g. by advising, supervising or operationalizing the decisions. The discussions lasted about two hours each, and were facilitated with a set of pre-defined statements related to knowledge practices. The statements were formulated according to a changing key theme relevant to forest management in each area (landscape-level management in Somero, biodiversity-oriented forest management in Joensuu and old-growth forests in Virrat) (Annex B). Moreover, the statements were structured to correspond to several important viewpoints using policy evaluation criteria (Mickwitz, 2003). In this study, the knowledge-related parts of the data were utilized. The organization of the focus group discussions is described in detail by Salomaa et al. (2016). Each discussion was recorded and transcribed verbatim.

Three training workshops for forest professionals were organized in November 2015 and April 2016, structured using themes that emerged from the focus group discussions. The aim of the workshops was to encourage the participants to identify the bottlenecks for biodiversity conservation in their work and to find solutions that are effective in their operational environment. There were altogether 35 FMA participants at the workshops, representing forest advisors, forest planners and FMA managers (for a more detailed description see Annex C). The locations of focus group discussions and workshops are presented in Fig. 1. Two workshops consisted of three sections dealing with different themes. The participants discussed why it is important to consider multiple forest-use and conservation measures in production forests, and the practices of distribution, acquisition and production of knowledge in the FOs' decision-making. In the end, they planned a micro-experiment to be conducted in their own work. Quotes from the training workshops are excerpts from the notes written by the first author and identified as "workshop 1 to 3".

In both phases of data collection, the researchers offered scientific insights and facilitated constructive discussions. The aim of combining two different data sets is to illustrate the different levels of knowledge flows in the process of deciding on the use of the forests. We wanted to explore how the more general views of knowledge use presented in the focus group discussions were visible in discussions with practical examples and planned experiments.

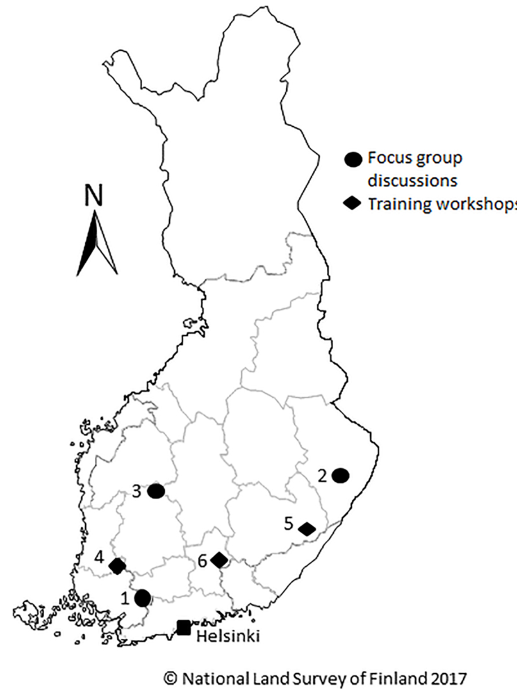

Fig. 1. Locations of the focus group discussions in Somero (1), Joensuu (2) and Virrat (3) and training workshops in Huittinen (4), Savonlinna (5) and Vierumäki (6).

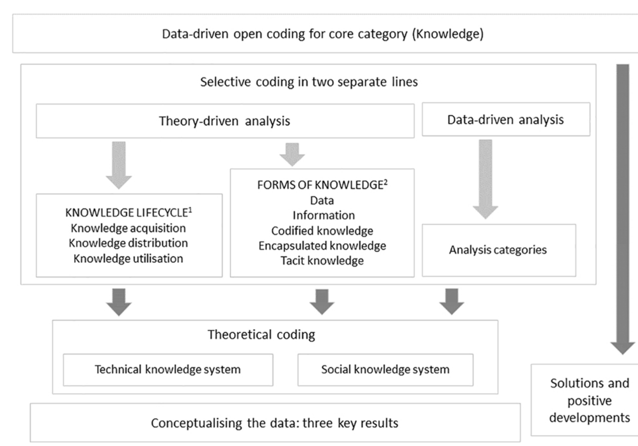

Fig. 2. Stages of analysis and categories used in the theory-driven analysis. [1] e.g. Evans et al., 2014; Fink and Ploder, 2009; Bhatt, 2001; [2] e.g. Evans et al., 2014.

3.3. Analysis

The purpose of the analysis was to understand the different meanings and roles accorded to knowledge in forest use and to understand the structures that determine and steer how knowledge is used or bypassed. Both data sets were analyzed together, applying the same principles. The analysis took place in three consecutive steps (Fig. 2). The first step was to identify the main categories in open coding of all data. After identifying the core category (knowledge) and categories mostly related to it, the analysis proceeded to selective coding (Holton, 2010). At this stage the coding was divided into two segments as part of the core categories were further conceptualized based on the theories of knowledge management. One line of analysis was theory-driven, focusing on the technical knowledge system. The other line of analysis was data-driven and focused on the social knowledge system. The more concise analysis categories created in the selective coding (step 2 of the

Table 1
Key results with descriptive examples and their occurrence in different parts of the data.

Key result	Examples	Focus group discussions	Workshops
i) Knowledge (data, codified, encapsulated and tacit) remains under-utilized	Databases are only partially open and available to service providers or other actors (such as authorities)	X	X
	Collected data should be converted into information more effectively, e.g. through taking advantage of the GIS-based conservation allocation programme Zonation	X	
	Encapsulated knowledge is not transferred correctly in the operation chain within an organization or from one organization to another		X
	Tacit knowledge of individual professionals is not passed on within the organization		X
	New tools like the conservation prioritization programme Zonation are needed, but they are received with suspicion or even opposed	X	
	Databases are not checked for the codified (or partly encapsulated) knowledge, though it exists. This applies to organizations' own databases and those available through the authorities		X
ii) Gaps in knowledge distribution	Forest professionals may have a negative attitude towards biodiversity protection and hence they fail to advise FOs about conservation options	X	X
	Organizations consider that biodiversity protection measures and advisory services related to them are a financial burden and hence tend to neglect them	X	X
	Advisory to FOs about biodiversity conservation options depends on the know-how/ competencies of the forest professional	X	X
	Knowledge is considered codified although it is encapsulated: The content received is not the same as the content put into the system. E.g. use of map symbols about nature information		X
iii) Perceived validity of the knowledge is dependent on the person producing it	Non-professional knowledge (e.g. plant or animal species observations collected by nature enthusiasts) is received with mixed expectations by some forest sector actors and eventually considered invalid	X	
	Requirements for the quality of data collection are set so high that it enables the receiving person/organization to ignore the information that non-professionals offer them	X	
	Inconsistent perception of forest owners; FOs are simultaneously i) expected to share their knowledge about their forest holdings - this information is (automatically) considered valid ii) considered ignorant of their forests, and the professionals bear the responsibility of having adequate knowledge of the forest	X	

analysis) were then abstracted into more theoretical, higher-level concepts in the third step of the analysis. In this phase the two lines of analysis were kept parallel. The data-driven analysis identified four categories in the selective coding: human factor, inconsistency or conflict, attitude or organizational culture and tools and resources. The higher level concepts in the theoretical coding (Fig. 2) were hence technical knowledge system and social knowledge system. The third line of analysis identified solutions and positive developments from the open coding. All analyses were conducted using the Atlas.TI programme, version 7.5. The phases of the analysis and main categories used in different stages of the analysis are presented in Fig. 2.

During the analysis, we found that the same themes and similar examples describing them were repeated in the focus group discussions and training workshops at all locations. This implicates saturation of the data and the universality of these themes. The interpretation of data and naming of the concepts were discussed with all authors with multidisciplinary backgrounds to increase the credibility and validity of the interpretation.

4. Results

In this section, we present the key results (Table 1) illustrated with quotes. Each key result characterizes the problem with knowledge in forest-related decision making and forestry practices from a different viewpoint. Some of the results are by nature more linked to the technical knowledge system, others to social knowledge system, but they are in many cases overlapping. This draws to focus on how the problems manifest in and intertwine between the knowledge systems. Knowledge transfer presents difficulties: between the different technical knowledge management systems (e.g. IT systems and their interfaces) or within the interplay of the technical and the social knowledge systems (e.g. social relationships and practices enacted by people and organizations). These problems are found within and between organizations. Finally, we present some on-going positive developments in the use of knowledge.

4.1. Knowledge (data, codified, encapsulated or tacit) remains under-utilized

The under-utilization of the existing data became apparent in six different ways. The first three examples are more linked to the technical knowledge system. Firstly, substantial amounts of information that have been collected and stored in authorities' databases, with public funding, are not necessarily available to other authorities or market-oriented forest and environmental sector organizations due to privacy regulations. This information is codified by nature. Forest service providers do not automatically have digital access to this information (e.g. biodiversity hotspots, relics of antiquity spots). In the quotations below[1], location, the stakeholder group that the speaker represents and data set (FGD = focus group interviews; WS = training workshop) are specified in parentheses after each excerpt.

> *We have some data but not all from the Hertta-database [state funded GIS-database for nature and environmental data] as far as I know. […] That is not in our IT-system. And, very likely, when it is not in our IT-system, it is not used. (Virrat, FGD9, forest authorities)*

Secondly, examples of inefficient conversion of collected data into information and knowledge were identified. Forest inventory data are not used to the fullest in biodiversity conservation planning. Authorities also hesitate to capitalize on Zonation, a GIS-based conservation area prioritization programme. The programme calculates the most promising spots for biodiversity protection based on forest inventory and other data on nature values. However, the data are not taken fully into use, because the resources to implement new conservation measures are

[1] translated from Finnish while maintaining original content, tone, and meaning; authors' clarifications in square brackets.

inadequate. The benefits of the programme are also weakened by some data being out-of-date or because there are insufficient skills or tools to analyze the data and convert those into information.

Forest Centre has used it [Zonation] somewhat, but there are certain connected challenges. One very obvious challenge is that a part of those high-priority areas may be mature forests and they have just been cut. Keeping data up-to-date is one clear weakness there. (Salo, FGD3, consultant)

Thirdly, codified or encapsulated knowledge is not transferred correctly in the operation chain within an organization or from one organization to another. Maps from different sources may display incorrectly when transferred to another organization's system. The information in the software system may be hidden behind additional clicks of the mouse, and remain unseen or is displayed differently in mobile and desktop versions of the software. There is often information that is considered additional, e.g. proposals for measures enhancing multi-objectivity. Such information stays encapsulated when the software is not developed to include it in a codified form.

A wish to IT-system: there should be some visualization (e.g. different colour) on the [electronic] map showing biodiversity hotspots or habitats of special importance [protected by Forest Act] - this would make it easier for the forest advisor to immediately see it on the map that at this site, I need to check the database more carefully. It would ensure that additional information added by forest planners is transferred to the advisor. (Savonlinna, WS2, FMA)

Organizations do not automatically transfer all available details about e.g. biodiversity or game management measures on a felling site to the subcontractor conducting the work. Only if the information is in the sales contract and hence legally binding is the information transfer assured.

Every forest owner has some kind of extra wishes for each felling site, if they have been asked. But these additional instructions are usually not transferred to the contractor's IT systems. Only if you put it in the sales contract it will go to the contractor. (Savonlinna, WS2, FMA)

Information about special [nature or game management-related] arrangements must be included in the felling site instructions. In the current operations model the information will not transfer to the contractor from the "biodiversity" data field of a forest management plan. (Vierumäki, WS3, FMA)

The fourth example is by nature more linked to the social knowledge system and it came up in the training workshops. Participants noted that there is no habit of asking and checking for nature-related information from their colleagues or from the forest authorities' office if the information is not automatically available in their systems, even when it is known that their databases are not necessarily up-to-date. This knowledge is encapsulated or tacit by nature. The problems are due to lack of IT systems supporting knowledge sharing and because there is no organizational habit of passing on or reaching for the information within the operation chain.

One challenge is how a forest advisor transfers the knowledge gained from the discussion with the forest owner when taking the order for forest management planning to the forest planner. (Huittinen, WS1, FMA)

It would be good if the planner could advise the felling machine operator or forest worker, but it would be realistic to have that information in the operating site instructions at least. (Savonlinna, WS2, FMA)

The last two examples about the under-utilization of existing knowledge illustrate the problems linked to the mismatch of two knowledge systems: the organizations' social norms, which direct how the employees work and the importance of social acceptance when new practices are introduced. In the workshops it was discussed that organizations' own databases, or those available to them, are not checked for the codified (or partly encapsulated) knowledge, because there is no habit of searching for or checking information. The mismatch of technical and social knowledge systems emerges when the information is available in the database but the user does not have the habit of using it.

It would be helpful for an advisor to see on the map that in this forest stand they have to check for additional information in the system. It would ensure that the information that the planner put there was transferred for further consideration. (Savonlinna, WS2, FMA)

In the last example, a new IT tool like the Zonation programme is acknowledged to increase the effectiveness of biodiversity conservation, but there is resistance to change and suspicion towards new ways of working, for example moving from planning one forest holding at a time to planning networks of protected areas.

Let's say we need to find the lekking sites for wood grouse, we definitely do not need Zonation for that. We know those sites anyhow. (Virrat, FGD8, scientist)

4.2. Gaps in knowledge distribution

In the focus group discussions, the most commonly noted problem with knowledge distribution was how forest advisors skip advising the forest owners about conservation possibilities. This theme came up in almost all discussions. Three reasons were identified: employees' lack of competence, employees' negative attitudes towards forest conservation, and the timber procurement targets of firms and pressure to make better profits. Problems with competencies were argued to be due to the short history of including biodiversity-related expertise in forester education and the regular updating required for related skills. It was often noted that in the forest service and timber procurement organizations, forest biodiversity conservation was not considered as important as timber production and harvesting. Hence, even the professionals working in those organizations fail to allocate time or other resources for considering biodiversity conservation.

Well, the forest advisors do play quite a key role in how they take the new law [renewal of the Forest Act in 2013 to enable continuous cover forestry] and the opportunities it provides, and how they present it to forest owners. (Joensuu, FGD4, regional council)

It varies by person how much the forest advisors in forest management associations can tell about the Biodiversity Programme. That's why not everybody is so fluent in discussing the conservation issues with landowners. (Virrat, FGD7, environmental authorities)

Well, the Biodiversity Programme is not the first thought for them, it is the log pile they want to see growing. That's the reason the timber purchasers are on the move. (Salo, FGD3, FMA)

In the workshops, the same problem with employees' competence and also to some extent their negative attitude towards conservation was acknowledged. The bottleneck of conservation was nevertheless identified to exist at a further point in the chain. Instead of advisors not discussing the conservation issues with FOs at all, the main problem was that the forest owner's wishes about conservation or nature management measurements were not passed to the next person on the operation chain. This information is often part of an advisor's tacit knowledge based on long experience with their customers.

The last example concerning knowledge distribution illustrates the mismatch between technical and social knowledge systems. It shows the misconception that all information in the databases is codified, and hence standardized between the sender and the recipient. In reality, part of that knowledge is encapsulated and would need certain background information to be understood. This means that the information may be interpreted differently from how the original producer meant it. Workshop participants highlighted the use of map symbols about nature information or FO's special wishes for management as an example.

However, organizations have no common instructions on how the available symbols in the GIS map software should be used and what they stand for. Hence the user cannot know what a certain map symbol means or how the object should be regarded in management operations.

It is difficult to put in many new map symbols or other markings. The usability and clarity of a map gets worse if in one forest stand there are many large map symbols of varying uses (content and expanse). (Huittinen, WS1, FMA)

4.3. Perceived validity of the knowledge is dependent on the person producing it

This key result represents other problems linked mainly to the social system of knowledge use. Non-professional or local knowledge was received with mixed expectations in the focus group discussions. It was claimed to be less trustworthy or valid, and in some cases even ideologically loaded. The role of officials as the primary information producers was emphasized by some discussants. Another way to emphasize the role of professional knowledge over non-professional or local knowledge was to demand that the information be of high quality.

The authorities produce knowledge, and [what is considered as] knowledge should not be opinions of nature hobbyists. (Salo, FGD2, forest owners' lobbyist)

If that information goes to wider use and in public, to be used [in decision-making], then it should hold true better. And that is quite a demand for the knowledge producer. (Joensuu, FGD4, forest administration)

Despite the reservations towards non-professional knowledge, the knowledge of forest owners about their own forest was considered valid and worth taking into account, though it is also mostly non-professional knowledge. The forest owner is also assumed to share their information with the forest service provider. At the same time, forest owners generally were considered (by peer owners and by forest and environmental professionals) not well-informed enough to know about important biodiversity spots in their forests, and the responsibility for producing and sharing biodiversity information is held by the forest professionals (both service providers and authorities).

Let's say, it's a small fraction [of forest owners] who know their forests well enough to realize that they have a splendid site there. (Virrat, FGD7, forest administration)

4.4. Positive developments in knowledge use

Three different themes for better management of knowledge were identified in the analysis: on-going positive developments, new work practices and changing competencies.

On-going positive developments are illustrated with two examples. Firstly, the use of nature information databases has been intensified with introduction of Zonation and Metsaan.fi[2] service. This reduces the under-utilization of existing knowledge and hence enhances the technical knowledge management.

Zonation seems to be fine and promising at least in the sense that if we think about flying squirrel observations, earlier we had some random observations from hobbyists here and there. This Zonation gives some estimates of where there could be valuable spots. (Salo, FGD3, consultant, inventory maker)

Secondly, according the focus group discussions, the non-professional knowledge production and co-operation between different organizations to collect and store data has been gaining acceptance. This indicates changes in social norms concerning socially accepted actors in forestry.

I've received information from other forest professionals, and also from these raptorial bird hobbyists whom I have been in contact with. (Virrat, FGD9, forest administration)

New work practices have been introduced or at least a need for those has been jointly recognized. In the workshops the participants noticed a need to learn to check the biodiversity hotspots from forest authorities' office or from the organization's own database, or getting in contact with the FO well before the forest planning starts. This is an example of a change in the social knowledge system, the organizational norm of how work is done.

Procedure for development: if you call the forest owner only when going to their forest, it is too late for discussions about their objectives and needs. (Vierumäki, WS3)

The conservation criteria built in and for the Biodiversity Programme have become widely accepted criteria for identifying and judging the nature values of forests, and hence they have been standardized in the assessments of forests. This is an example of conversion of scientific information into tacit knowledge, practical knowhow, and enhancement of co-operation between different actors as well as in flows of information. The social acceptance of that information allows it to be acknowledged as shared knowledge.

One thing that has resulted from the Biodiversity Programme is that its criteria for compensated conservation has become somehow standardized, universal criteria for rating the biodiversity values in forests. Practitioners use it all the time, rating whether a site would be first class, or rather second or third, even when they are not rating it for the Biodiversity Programme. (Virrat, FGD7, environmental NGO)

Lastly, an example of changing competencies shows that with regular training and working with conservation issues, the expertise level of forest professionals is getting better. The attitudes of organizations and individual forest professionals are slowly becoming more positive towards more diversified forest uses and biodiversity protection. Both social and technical knowledge systems have been adapted to better accommodate biodiversity-related practices and values. It also has enhanced the understanding of the reasoning behind technical biodiversity knowledge.

I guess we have become better in recognizing [Biodiversity Programme -sites] but I would say we are only half way there. These are quite difficult issues. If I speak about myself, little by little I have improved and I have learned and started to see the relevant characteristics [for biodiversity], I guess it was much worse a few years ago. (Virrat, FGD7, FMA)

5. Discussion

Different forms of knowledge - codified, encapsulated or tacit - are taken into account differently in the implementation of forest owner's decisions about their forests, as hypothesized in the first research question. Our first key result exemplifies that codified knowledge dominates, whereas the importance of encapsulated and tacit knowledge is underrated. Knowledge production about forests has concentrated on codified nature data and the technical systems supporting it are built mainly for processing codified knowledge i.e. information. It is highly standardized and hence efficient to store and distribute in IT systems, but also rather one-sided: only those pieces of information that have been selected to be stored in the standardized way will be used (see Jasanoff, 2004). Because of the strong tradition of intensive timber production in Finland, forestry-related knowledge has dominated the knowledge use. This was visible in the data: most knowledge related to biodiversity or nature values was noted to be "extra" or "additional" and needed to be added, transferred and looked for with greater effort

[2] Metsaan.fi is a state funded internet service platform that offers forest inventory and nature knowledge to FOs. It also serves as a contact point between FO and forest authorities as well with forest service providers.

than codified forestry-related knowledge. This additional information is encapsulated by nature. For example, forest owners' biodiversity-related objective setting for forest management operations are entered into operation planning IT systems as encapsulated knowledge that does not transfer automatically to other systems. This indicates a lower perceived importance of such knowledge for decision making. This result is in accordance with Rekola et al. (2010) who found that timber production was valued more highly than nature conservation by professionals working with timber procurement.

With the diversification of forest use, knowledge needs have also diversified, but IT systems have not been modified at the same pace to include additional knowledge. The lack of availability of certain databases to all actors are partly due to legal requirements of protection of personal data. Mainly, however, it is the result of incompatibilities between the IT systems of different organizations and lack of interfaces. Much data are collected but insufficient attention and resources are allocated to take full advantage of those. However, positive developments include the intensification of forest inventory and nature information use with the introduction of the previously mentioned Zonation program and Metsaan.fi service.

Our results indicate that the knowledge in the technical system remains partly unused because of the social system, i.e. the organizations and people within them lack the habit of fully exploiting the databases, or the social structures prevent them from acknowledging some knowledge or some producers of knowledge. The role of authorities in contrast to "hobbyists" as the primary information producers was emphasized in the focus group discussions. Two explanations come to mind: firstly, biodiversity protection and planning of the use of natural resources is predominantly based on scientific knowledge, although local knowledge is increasingly recognized as valuable (Joa et al., 2018). Secondly, emphasis on scientific knowledge production and underlining the importance of formal expertise in objective interpretation of that knowledge has reinforced forest professionals' authority in the use of forests in contrast to lay persons (see e.g. Maier and Winkel, 2017). However, the knowledge production system has inevitably changed to include new actors and new practices (Soma et al., 2016), which undermines the old authority of professionalism. The perception of expert-driven knowledge production as objective in contrast to other knowledge production disregards the view that all knowledge is partial and affected by the social and historical context in which it is created (Fortmann and Ballard, 2011; Haraway, 1988). Ignoring parts of knowledge and its producers decreases the quality of decisions and increases the risk for disputes.

Forestry actors also tend to protect their decision-making power about forest-related issues by shutting others outside (Maier and Winkel, 2017). This explains the result that the knowledge of forest owners about their own forests is sometimes considered valid although forest owners generally are considered not well-informed enough to know about important spots for biodiversity in their forests. Timber production orientated forest owners, in contrast to biodiversity-oriented ones, are considered by forestry actors as "one of us", and hence their knowledge is also worth taking into account. Gootee et al. (2010) made the same observation. In their study, well-informed FOs were treated as respected stakeholders in issues concerning their forests by forest professionals, whereas less active forest owners were considered less-informed and approached with a more hierarchical expert-layperson relationship.

Although non-professionals were partly regarded with suspicion, many group discussion participants also highlighted the importance of non-professionals as knowledge producers, especially with the diminishing resources in the state budget for data production. There are also attempts to collect tacit nature information from other forest professionals into collective databases. Acknowledging and sharing different sources of data, from FOs themselves, forest professionals and local stakeholders increases the information flow (Fortmann and Ballard, 2011). To this end, easy-to-use data provision interfaces, guidelines, and practices – with checks and balances for data quality – need to be established.

The third research question addressed the points of discontinuity in information flows within and between organizations and actors. In the group discussions, the inadequate distribution of knowledge related to biodiversity conservation from the organizations advising FOs or purchasing timber was a repeated reason for gaps in the knowledge flow. This was explained mainly by lack of skills or obstructive attitudes. Besides the competencies, the financial targets of forest sector companies were also found to hinder advising on biodiversity. To fully match the services provided with the increasing interest of FOs to maintain biodiversity in their forests, the organizations should make biodiversity protection a priority and allocate resources accordingly. Increasing knowledge about biodiversity alone does not change the behaviour of the companies that aim to maximize timber yield (Peltola, 2013). Positive developments were noted, too. Training about nature conservation and management issues is offered regularly by employers and by forest and environmental authorities, and the attitudes of organizations and individual forest professionals are more positive towards biodiversity protection than earlier.

Another problem was identified with a misconception that all information in the databases is codified although part of it is actually encapsulated. The content of encapsulated knowledge does not transfer correctly within organizations because, without common agreements or communication with colleagues, the content of encapsulated knowledge may be ambiguous. This result coheres with the results of Hokajärvi (2002) on dropping knowledge within the forest regeneration planning and operation chain. In some organizations there are social practices of not checking the databases for existing information. This might be at least partly due to the fact that the data in the databases, e.g. about the habitats of special importance, are not considered reliable (Peltola and Tuomisaari, 2015).

Many companies providing forest services in Finland are small- or medium-sized. Though knowledge management efforts have historically focused on large, multinational companies, they are crucial for the success and growth of small and medium-sized enterprises as well (Fink and Ploder, 2009). Knowledge is a strategic asset to a company that can be used to gain competitive advantage (Grant, 1996). According to our results, the financial burden of the extra work required for the consideration of biodiversity was an important reason why these issues are not presented to FOs. However, sometimes the problem was also that the suggestions that the forest planner made, or the advisor planned, were not carried out in practice because the information did not reach the contractor. Enhancing knowledge flows could also benefit the companies financially and increase their competitiveness. This could encourage them to invest in enhanced management of encapsulated and tacit knowledge, too.

The result that tacit knowledge does not move between the professionals within an organization is connected to organizational social practices. Schön (1987, pp. 22–31) describes tacit knowledge as so deeply internalized that the actor cannot identify its origin or describe it. This internalized knowledge is problematic in the sense that it cannot be transferred to colleagues through the technical knowledge management systems. Our results indicate that the technical knowledge system dominates the way forest organizations operate also internally, while the functioning of the social knowledge system would be reinforced by informal communication channels like e-mail, intranet and coffee table discussions (Bhatt, 2001). We recommend implementing organizational structures and practices that encourage knowledge exchange and learning between employees, which would also enhance the flow of encapsulated and tacit knowledge (Stenberg, 2012) and hence balance the utilization of different forms of knowledge. This could be approached, for example, via intra-organizational knowledge-sharing software, dedicated knowledge co-construction events, employee exchange programmes, and informal work-unit cross-pollination practices.

The results of this study are not intended to be generalized as such, but we believe that they present a recognizable phenomenon in the wider context of management of private forests for multiple purposes. The focal themes were repeated in several discussions and at different locations. Despite the effort made to assemble as balanced representation as possible from different stakeholder groups, our data lacks the views and opinions of the wider civil society and e.g. representatives of timber procurement companies. In addition, it is possible that the forest professionals and owners that attended the group discussions were more orientated towards multi-objective forest management, including biodiversity conservation, than traditional industrial forestry. The discussions were also dominated by persons who were there in expert roles, mostly men. To enhance the multi-perspective analysis of the issues, more research is needed to enquire other forest users about their knowledge needs and ways to improve knowledge co-production and multi-objective management of forests.

6. Conclusions

This study identified problems with knowledge use that are related to the functioning of the technical or social knowledge system or to the mismatch of these systems within the management of privately-owned forests in Finland. The results show many points of discontinuity in the flow of knowledge within and between forest-related actors and organizations. To enhance the knowledge flows, more attention must be paid to social structures that guide how knowledge is used and validated within the organizations, and to a more balanced way to produce and utilize different forms of knowledge. Development of IT systems to include not only forestry-related information but also biodiversity and other information in codified form would address the problems of the technical knowledge system.

The forest organizations should pay attention to the practices of sharing encapsulated and tacit knowledge within the organization. The positive development of including local ecological and social knowledge from non-professional sources alongside professional knowledge should be further strengthened. When doing so, the equality and fairness of the burden of producing the knowledge and the distribution of benefits from using it must be emphasized.

We developed a theoretical frame in this study to identify the different forms of knowledge and their roles in technical or social knowledge systems. The frame can facilitate organizations to identify the points of discontinuity in their knowledge use and reasons behind them. This study contributes to the practical development work of forest sector organizations and their networks to better integrate multiple uses of forests in their business models and to develop the knowledge systems needed to do so.

Declaration of Competing Interest

The authors declare no conflict of interest. Funding sources have not been involved in preparation of this study.

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Annex A Participants of focus group discussions

The locations of focus group discussions were chosen to cover the focal areas of interest for the project. The locations for training workshops were selected to cover different areas in Finland and to be easily accessible for participants from different locations (Table A1).

Table A1
Focus group participants. Three parallel groups were organized in each location. (Table modified from Salomaa et al., 2016).

Stakeholder	Somero	Joensuu	Virrat[c]
Scientist	3[d]	3	3
Landowner	3	7	3
Environmental administration (ELY-Centre for Economic Development, Transport, and the Environment)	2	1	1
Forest administration (Forest Centre or Ministry of Agriculture and Forestry)	3	4	2
Forest Management Association (Forest owners' association)	3	4	3
Nature conservation NGO	3	–	1
The Central Union of Agricultural Producers and Forest Owners	1	–	1
Regional Council	1	1	–
Tapio (consulting services)[a]	2	–	–
Metsähallitus[b]	1	1	–
Communications entrepreneur	–	–	1
Inventory maker/consultant	2	–	–
Total of participants 60	24	21	15
of which female (excluding the scientist facilitating the discussion)	10	10	4
of which male (excluding the scientist facilitating the discussion)	14	11	11

[a] Tapio consulting services provides solutions for efficient and sustainable forest management and bio economy both for public and private sector.
[b] Metsähallitus administers the state forests; it runs business activities but is also responsible for public services of protected areas.
[c] In Virrat one of the local organizers has taken part in one of the discussions and hence the number of participants differs from Salomaa et al. (2016). The first author has participated in one discussion: the author is listed as a scientist in the participant list, but their contributions have been left out of the analysis.
[d] The last author has participated in one of the Somero discussions: the author is listed as a scientist in the participant list, but their contributions to the discussion have also been left out of the analysis.

Annex B Statements used for facilitating the focus group discussions

Statements used in the first focus groups in Somero. The statements for each location were compiled around local conditions so that the themes were relevant for the current situation in the use of private forests there. The themes were landscape level management of forests and cultural landscapes (Somero), biodiversity-oriented forest management (Joensuu) and old-growth forests (Virrat). A framework of Mickwitz's (2003) policy evaluation criteria (relevance, impact, effectiveness, persistence, flexibility, predictability, legitimacy, transparency and equity) was used to ensure the handling of different aspects. Although the statement phrasing was slightly modified from these for the discussions in Joensuu and Virrat, the basic meaning behind each statement remained the same. Each group discussed one to three statements under six criteria. This annex is originally from Salomaa et al. (2016) and Paloniemi et al. (2018) (Table B1).

Table B1
Statements used in the first focus groups in Somero.

Criteria	Statements used in the focus groups to stimulate discussion
1. Relevance *Do the goals of the instruments cover key environmental problems?*	Biodiversity conservation through management is the most important environmental target in Rekijokilaakso. The forest Biodiversity Programme brings additional value to the conservation of traditional biotopes in Rekijokilaakso. Persons who implement Biodiversity Programme should regularly meet with scientists and they should negotiate the targets together.
2. Impact *Is it possible to identify impacts that are clearly due to the policy instruments and their implementation?*	Biodiversity Programme has also had other impacts than biodiversity conservation, e.g. the acceptance of nature conservation has increased. The Biodiversity Programme has improved or disrupted social relationships among different actors in the area. Management of traditional rural biotopes advances forest owner satisfaction with biodiversity conservation.
3. Effectiveness *To what degree do the achieved outcomes correspond to the intended goals of the policy instrument?*	Altering the management actions of economically utilized forests can yield more positive effects on forest species than increasing conservation areas. Forest owners should try to find solutions together for protecting biodiversity at the landscape level. The forest management association [forest owners' service and lobby organization] is closer to landowners than nature conservation authorities are, and therefore negotiates more smoothly with landowners.
4. Persistence *Are the effects persistent in such a way that they have a lasting effect on the state of the environment?*	The proportion of fixed-term contracts should be decreased for the benefit of permanent conservation agreements. Biodiversity-oriented forest management projects improve the network of conserved areas if they are situated near national parks or other valuable conserved areas. [Biodiversity-oriented] Forest operations that are performed only once can cause permanent improvement.
5. Flexibility *Can the policy instrument cope with changing conditions?*	Forests could be cut in an agreed manner prior to the permanent conservation of an area to save costs. When prioritizing Biodiversity Programme conservation areas, one should consider how nature features could be conserved in a changing climate. Fixed-period conservation agreements are better than permanent agreements because they enable including new targets in nature conservation programmes in the future.
6. Predictability *Is it possible to foresee the administration, outputs and outcomes of the policy instrument?*	When planning the Biodiversity Programme, the amount of required knowledge, advice and resources provided were evaluated better than during the Natura 2000 programme. Future actions can be planned in a way that conserves biodiversity based on current knowledge.
7. Legitimacy *To what degree do individuals and organizations, such as non-governmental organizations, interest organizations and firms, accept the environmental policy instrument?*	Forest-based livelihoods should be considered already during the preparation of land-use planning to combine different objectives. Other actors besides landowners perceive Biodiversity Programme as fair and legitimate. An initiative from forest owners is essential for the acceptance of cross-border conservation planning.
8. Transparency *To what degree are the outputs, outcomes of the environmental policy instrument, as well as the processes used in the implementation, observable to outsiders?*	Concepts relevant to conservation, such as "meta-population" and "connectivity", should be better explained in biodiversity advising. Knowledge of valuable sites on private land belongs to all citizens, and thus information concerning, e.g. the existence of flying squirrel, should be openly accessible if it does not threaten the protection of the species. Making a Biodiversity Programme conservation agreement or a biodiversity-oriented forest management agreement is easy, and rationales for compensation are easy to understand.
9. Equality *How are the outcomes and costs of the environmental policy instrument distributed? Do all participants have equal opportunities to take part in and influence the processes used by the administration?*	Regionally valuable areas should be evaluated systematically, e.g. using the Zonation programme [ecological prioritization software], to direct the marketing of conservation opportunities to the owners of valuable sites. Authorities should make conservation contracts with all landowners using the same eligibility and compensation rules despite differing nature values. Landowners' and nature enthusiasts' knowledge does not impact the selection of Biodiversity Programme conservation areas strongly enough.

Annex C Organization of training workshops

Three training workshops for forest professionals were organized with altogether 35 participants in November 2015 and April 2016, structured using themes that emerged from the focus group discussions. The aim of the workshops was to encourage the participants to identify the bottlenecks in biodiversity conservation in their work and to find solutions that are effective in their operational environment. The participants represented forest advisors working daily with FOs, forest planners who conduct field inventories for the holding-level forest management plans and personnel with managerial duties for forest management associations. The workshops were organized in co-operation with the umbrella organization of forest management associations and representatives from the state forest administration. They were however open to all, and one participant represented regional wildlife management organization.

Two workshops consisted of three sections dealing with different themes. The first theme asked the participants to discuss why it is important to consider multiple forest use and conservation measures in the production forests. The second theme highlighted the practices of distribution, acquisition and production of knowledge in the FOs' decision-making. The last theme encouraged participants to plan a micro-experiment about the themes discussed to be conducted in their own work. Each section started with a short introductory presentation by researchers and continued with small-group discussion, with a set of questions defined by the researchers. The sections finished with a joint discussion. The third workshop focused on the first and second themes of the other workshops. It started with an introductory presentation followed by facilitated group discussions. The workshop ended with a plenary discussion involving all the participants (Table C1).

Table C1
Training workshop participants (excluding the scientist and local organizers).

Participants	Huittinen	Savonlinna	Vierumäki[a]
Forest advisor (advisory services for forest owners)	3	5	–
Forest planner (field inventories and forest management plans)	5	5	
Managers (managerial tasks within the FMAs)	1	2	–
Number of organizations represented	8	4	
Total of participants	9	12	14
of which female (excluding the scientist facilitating the discussion)	2	1	
of which male (excluding the scientist facilitating the discussion)	7	11	

All training days were followed by field trips (in the afternoon or the following day) where the themes were further discussed in the more concrete cases.

[a] The Vierumäki workshop was organized as part of a larger training event for forest management planners. There were participants from every part of country, all working with the tasks of forest management planning (FMP). This part of the data is from two discussion groups, to discuss same issues of motivations to take multi-objectivity better into account in the planning of forest use and practices to enhance knowledge use in forest management. Before the group work there was an introductory presentation about the themes for the entire group of event participants. Each of these two discussion groups had about seven participants, both men and women. Other event participants took part in other group discussions with other FMP related themes (e.g. use of remote sensing data as source data for FMP). Researchers facilitated the discussions and took notes. After the group work the results were discussed in plenary.

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